EGG-10617-1062
OCTOBER 1990

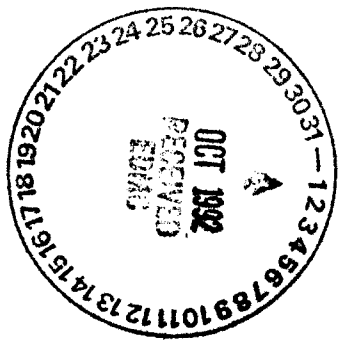
AN AERIAL RADIOLOGICAL SURVEY OF THE

HANFORD SITE

AND SURROUNDING AREA

RICHLAND, WASHINGTON

DATE OF SURVEY: JULY–AUGUST 1988



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ABSTRACT

An aerial radiological survey was conducted over the Department of Energy's Hanford Site near Richland, Washington, during the period 5 July through 26 August 1988. The survey was expanded, and additional flights were conducted to the east of the site and along the banks of the Columbia River down to McNary Dam near Umatilla. The survey was flown at altitude of 61 meters (200 feet) by a helicopter containing 17 liters (eight 2 in × 4 in × 16 in) of sodium iodide detectors.

Gamma ray data were collected over the survey area by flying north-south lines spaced 122 meters (400 feet) apart. The processed data indicated that detected radioisotopes and their associated gamma ray exposure rates were generally consistent with those expected from normal background emitters and man-made fission/activation products resulting from activities at the site. External exposure rates were generally 10 microroentgens per hour (μR/h) with some operating areas over 1,000 μR/h. The radiation levels over more than 95% of the site are due to normal background exposure rates.

The survey of the Hanford Site was requested by the United States Department of Energy (DOE) and was conducted by the DOE's Remote Sensing Laboratory (RSL). The RSL is operated for the DOE by EG&G Energy Measurements, Inc. (EG&G/EM), an independent contractor.

CONTENTS

1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains the Remote Sensing Laboratory (RSL) to provide a remote sensing capability for use at all sites of interest to the DOE and other government agencies where authorized by the DOE. The RSL is operated by EG&G Energy Measurements, Inc. (EG&G/EM) under the direction of the DOE Nevada Operations Office as part of an integrated contract. One of the major functions of the RSL is to manage an aerial surveillance program called the Aerial Measuring System (AMS).

Since 1958, the AMS and its predecessor, the Aerial Radiological Measuring System (ARMS), have continued a nationwide effort to document the radiological character surrounding specific sites of interest. These sites include nuclear power plants, nuclear waste repositories, and research and development laboratories where radioactive materials may be used. The AMS has the capability of performing large-area radiological mapping, high altitude aerial photography, multispectral photography, multispectral aerial scanning, and airborne gas and particulate sampling. The survey operations are conducted at the request of federal or state agencies and are under the direction of the DOE.

2.0 SITE DESCRIPTION

DOE's Hanford Site (Figure 1) covers an area of approximately 1,450 sq km (560 sq mi) in the southeast quadrant of Washington state. The site is just north and west of Richland, Washington. The Columbia River flows through the northern portion of the site, and as the river turns southward, it becomes part of the eastern boundary of the Hanford Site.

3.0 SURVEY PROCEDURES AND EQUIPMENT

3.1 Operational Support

A Messerschmitt-Bolkow-Blohm (MBB) BO-105 helicopter (Figure 2) was used for the survey. The aircraft carried a crew of two along with a fourth-generation version of a lightweight, specialized data acquisition and recording apparatus, the Radiation and Environmental Data Acquisition and Recorder (REDAR IV) system. One detector pod was mounted on each side of the helicopter. Each pod contained four 5.1-cm × 10.2-cm × 40.6-cm (2-in × 4-in × 16-in) log-type, thallium activated sodium iodide, NaI(Tl) gamma ray detectors. Signals from the eight detector logs were summed electronically to give a single energy spectrum of high sensitivity. The summed signal gain was adjusted so that the analog-to-digital converter would map a 4.0 MeV gamma ray spectrum into the REDAR's memory.

The REDAR contained five microprocessor-controlled subsystems used in the collection of survey information. The first, a control subsystem, was responsible for collecting gross count, live-time, spectral, and aircraft positional data at one-second intervals. Additionally, the first microprocessor sent the data to the tape subsystem every four seconds for recording. Spectral data were collected in two memories which operated in a time-share mode (*i.e.*, one memory collected data while the other was being read). The second microprocessor controlled the display subsystem which collected and formatted the data for display on two cathode-ray tubes aboard the aircraft. The third microprocessor controlled the tape subsystem, composed of the processor and a dual digital cartridge recorder. The system recorded four one-second blocks of data on magnetic tape every four seconds. Each data cartridge contained sufficient magnetic tape for approximately one hour of data collection time. The fourth microprocessor controlled the steering indicator subsystem used to aid the pilot in flying straight, predetermined flight lines. The fifth microprocessor controlled a special usage subsystem not employed during this survey.

3.2 Aircraft Positioning

The helicopter position was established with two systems: a Trisponder ultrahigh-frequency ranging system and a radar altimeter. The Trisponder master unit, mounted in the aircraft, interrogated two remote transceivers which were mounted in an appropriate geometric configuration several kilometers outside the survey area. By measuring the round-trip propagation time between the master and remote units, the master unit computed the distance to each. These distances were buffered in one-second intervals, and the buffered data were recorded on magnetic tape every four seconds. In subsequent computer processing, the data were converted to position coordinates and scaled to fit an aerial photograph.

The radar altimeter aboard the helicopter similarly measured the time lag for the return of a pulsed signal and converted this to aircraft altitude. For this survey, altitude accuracy was ±1 m or 3%, whichever was greater. These data were also recorded on magnetic tape so that variations in gamma ray signal strength caused by altitude fluctuation could be accurately compensated.

3.3 Survey Procedures

The survey area covered approximately 1,630 sq km (630 sq mi). Area coverage was obtained by flying a series of parallel lines at an altitude of 61 m (200 ft) above ground level (AGL) at a ground speed of approximately 148 kph (80 kts). Distance between the lines was 122 m (400 ft). Before proceeding to the survey area and again upon returning from the area, a test line was flown over an undisturbed area and over a wide area of the Columbia River at survey altitude and speed to monitor changes in airborne radon activity. Upon completion of the survey, a serpentine line was flown over the survey area. Data from the serpentine flight are typically used to augment test line data; and in the case of a large-area survey such as Hanford, they have proven to be invaluable.

3.4 Data Processing Equipment

The data recorded on the magnetic tape cartridge by the REDAR IV during the survey were processed in the field with the Radiation and Environmental Data Analyzer and Computer (REDAC) system. This system was configured around a 32-bit, Data General Corporations (DGC) MV/7800 XP computer system mounted in a mobile data processing laboratory (Figure 3). An extensive inventory of software and supporting equipment was available for detailed data analysis.

Additional processing was performed at the RSL in Las Vegas, Nevada, with a 32-bit DGC MV/8000 II computer system.

4.0 NATURAL BACKGROUND RADIATION

Natural background radiation originates from the decay of radioactive elements present in the earth and from cosmic rays entering the earth's atmosphere from space. The principal radioactive elements present in the earth are uranium and its decay products, thorium and its decay products, and radioactive potassium. Natural terrestrial gamma radiation originates from the decay of these elements. Local concentrations of these nuclides typically produce radiation levels ranging from 1 to 15 μR/h within the United States.[1] The natural terrestrial radiation levels are dependent upon the geologic character immediately surrounding the point of interest.

One member of each of the uranium and thorium decay chains is a noble gas (radon) which can both diffuse through the soil and be transported in the air to other locations. Therefore, the level of airborne radiation depends on the meteorological conditions, the mineral content of the soil, and soil permeability, etc., existing at each location at a particular time. Typically, airborne radiation contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays, the space component, interact in a complex manner with the elements of the earth's atmosphere and soil. These interactions and the cosmic rays themselves produce an additional natural source of radiation. Radiation levels due to cosmic rays vary with elevation and geomagnetic latitude. Typical levels in the United States range from 3.3 μR/h in Key West, Florida, to 7.2 μR/h in Flagstaff, Arizona.[1]

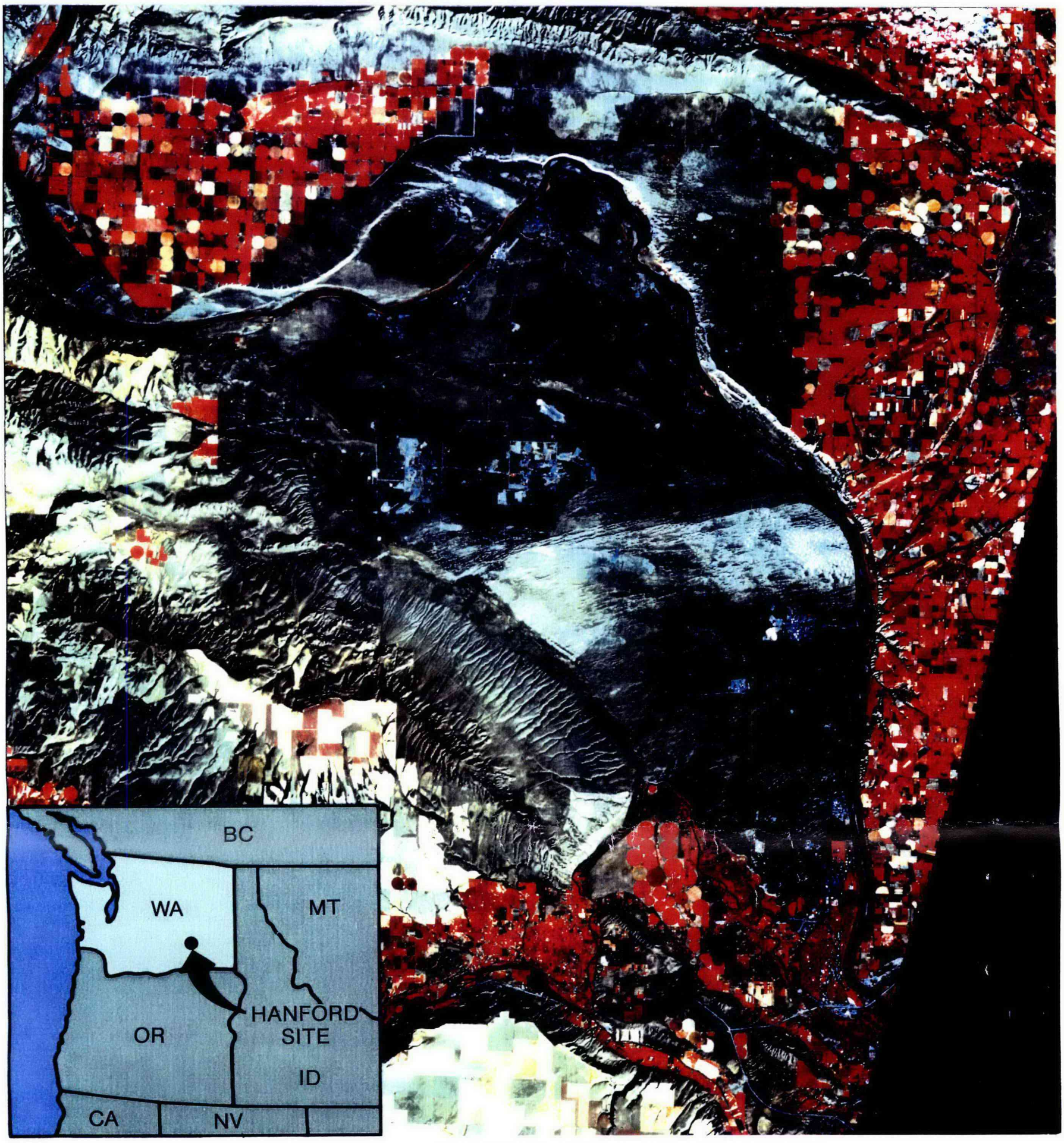


FIGURE 1. *SATELLITE INFRARED IMAGE OF HANFORD SITE AND SURROUNDING AREA*

FIGURE 2. *MBB BO-105 HELICOPTER WITH DETECTOR PODS*

FIGURE 3. *MOBILE COMPUTER PROCESSING LABORATORY*

5.0 ANALYSIS AND RESULTS

The aerial survey data were processed to show the areas surveyed and the general exposure rate levels and to define areas of man-made radionuclide activity. Figure 4 displays exposure rate contours based on gross counts collected by the airborne system. Figure 5 shows the results of the data when processed in a manner that suppresses the natural component. Comparing Figures 4 and 5, it is clear that suppressing the natural component better defines those areas of man-made activity. More importantly, it is also clear that the implied added exposure from man-made radionuclides in many areas is small. The exposure rates over more than 95% of the site are consistent with background. The aerial system can only measure the terrestrial gamma rays originating on the surface or near the surface. It cannot sense gamma rays originating from deep within the ground.

Data collected on the flight downriver to McNary dam near Umatilla showed activity consistent with natural background. In addition, the area surveyed to the east of the Columbia River was also consistent with natural background, In both cases, processed data exhibited no man-made activity.

The terrestrial exposure rate was estimated by extracting the nonterrestrial contributions from the gross count rates over the survey area, then multiplying the results by an empirically derived conversion factor. It should be noted the terrestrial exposure rate was normalized to 1 meter AGL, but only as a large-area average. Aerial systems integrate radiation levels over an area whose diameter may be 10 times the height of the platform above the ground. This is a function of gamma ray energies, their origin within the soil matrix, and the response characteristics of the detector package. For activity fairly uniformly distributed over large areas, which is typical of natural background radiation, the agreement between ground-based readings and those inferred from aerial data is generally quite good. Because of the large-area integration of the airborne system, localized anomalies will appear to be spread over a larger area with lower activity than actually exists on the ground. Therefore, for localized anomalies, ground-based measurements will not agree very well with the aerial results. The aerial data, therefore, simply serve to identify the existence of such anomalies. Ground-based surveys are required for more accurate definition of the spatial extent and intensity of the anomaly.

Each of the anomalous areas shown in Figure 5 has been scaled up and included here as separate figures to assist ground-based surveys. Figures representing the net gamma ray spectra collected over the anomalous areas are also included. The net gamma ray spectrum is the resultant spectrum when the natural component is removed.

The spectra have an identifying key in each right hand side which corresponds to labeled areas of interest on the accompanying isoradiation contour figure. An example is shown below in Figure 6.

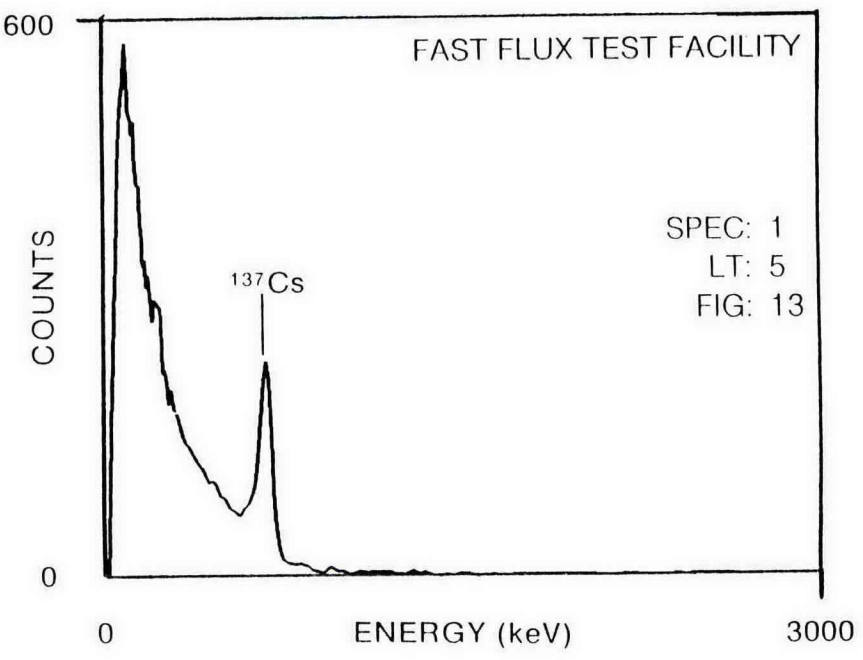


FIGURE 6. *SAMPLE SPECTRUM*

This spectrum is from Area of Interest 1 on Figure 13 and had an acquisition live time of 5 seconds.

Many of the spectra do not have readily identifiable photopeaks but rather a smear or continuum. This is often a result of shielded radionuclides or high count rates. Those spectra that have low count rates and no identifiable photopeaks are good examples of shielded nuclides. Those spectra where the count rate is quite high and which have no identifiable photopeaks are good examples of spectral distortion.

Figure 7 shows the location of each scaled-up anomalous area. It is provided as a quick key to aid the reader in locating specific areas of interest. Figures 8 through 25 are the spectra and the isoradiation contours for the surveyed areas.

CONVERSION SCALE	
COLOR CODE	TERRESTRIAL EXTERNAL EXPOSURE RATE AT 1 METER μR/h*
	5
	8
	15
	150

* Terrestrial external exposure rates are inferred from aerial data collected at 61 m (200 ft AGL). For total external exposure rate a cosmic contribution of 3.7 μR/h should be added.

FIGURE 4. *TERRESTRIAL EXTERNAL EXPOSURE RATE ISORADIATION CONTOURS OVERLAID ON A TOPOGRAPHICAL MAP OF THE HANFORD SITE*

MAN-MADE GROSS COUNT (MMGC) CONVERSION SCALE	
COLOR CODE	**COUNTS PER SECOND**
	1,200
	7,000
	70,000
	700,000

The data shown have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

FIGURE 5. *MAN-MADE ISORADIATION CONTOURS OVERLAID ON A TOPOGRAPHICAL MAP OF THE HANFORD SITE*

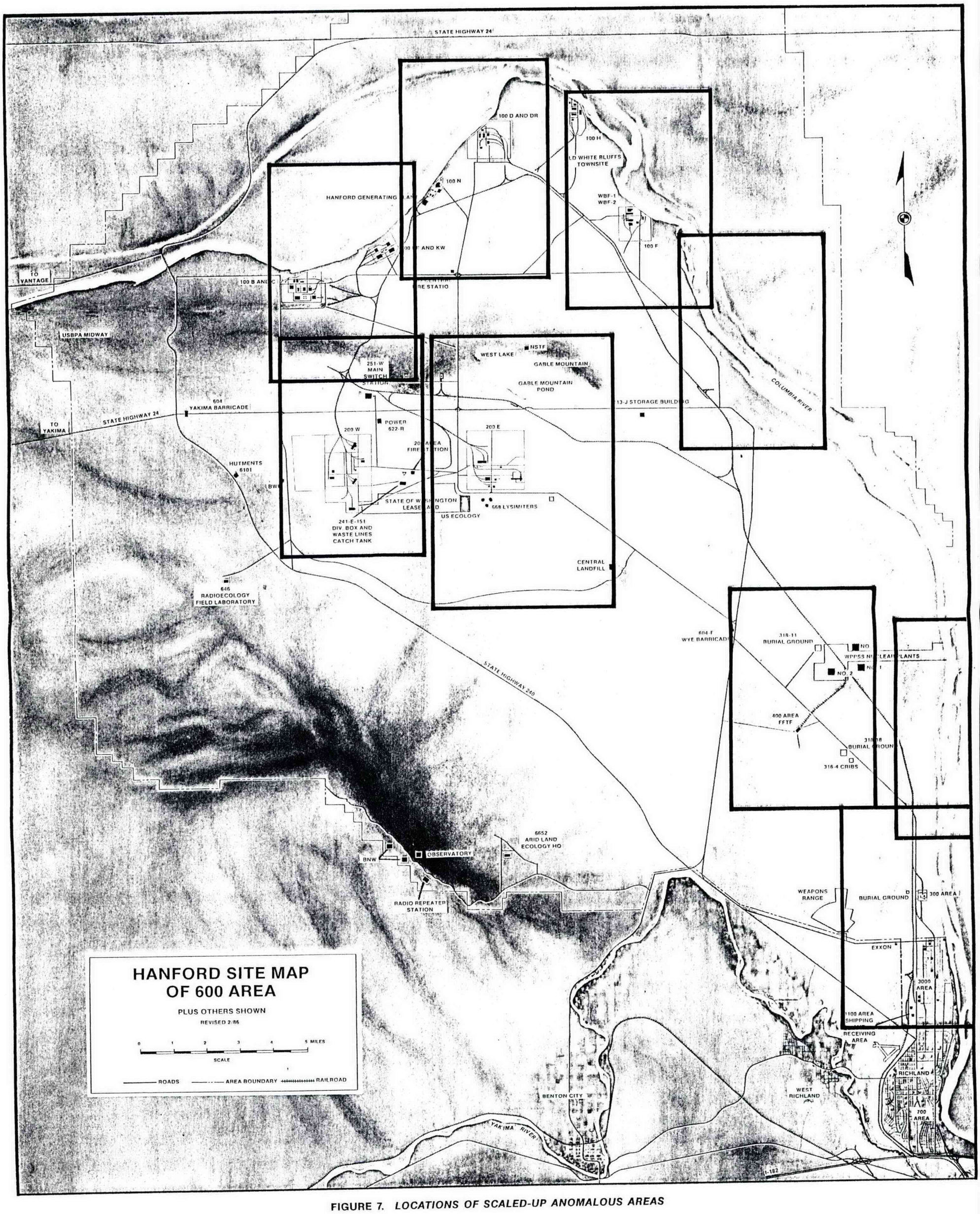
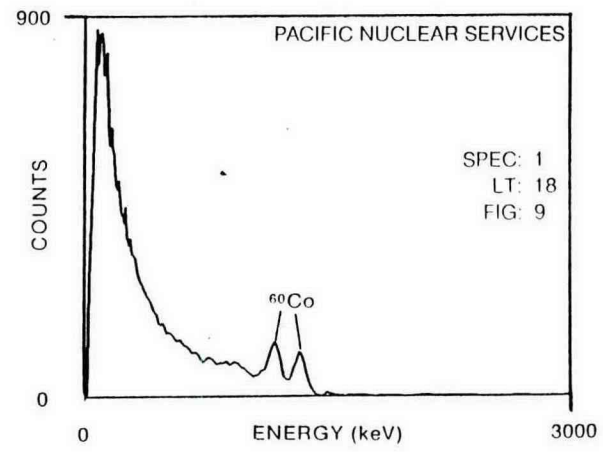
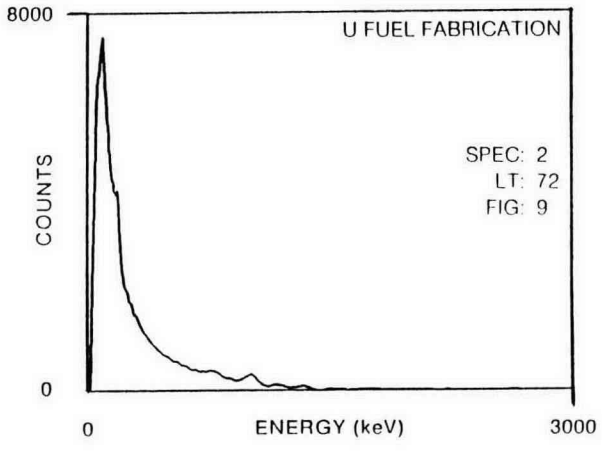
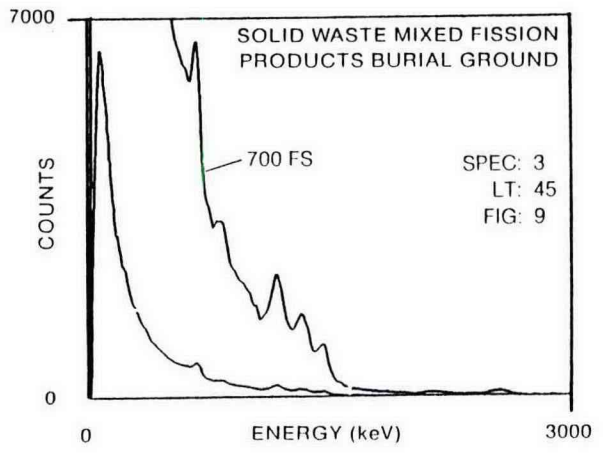
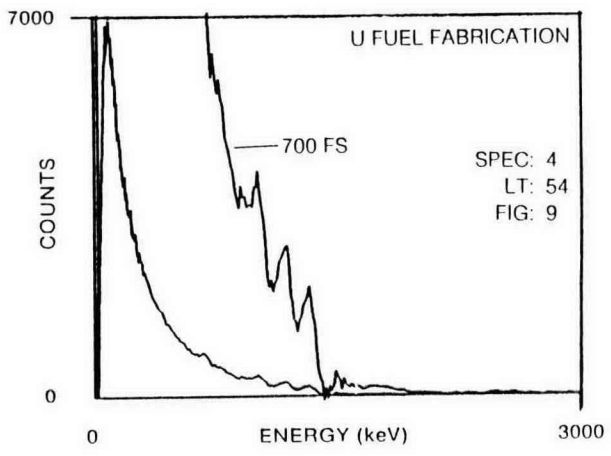


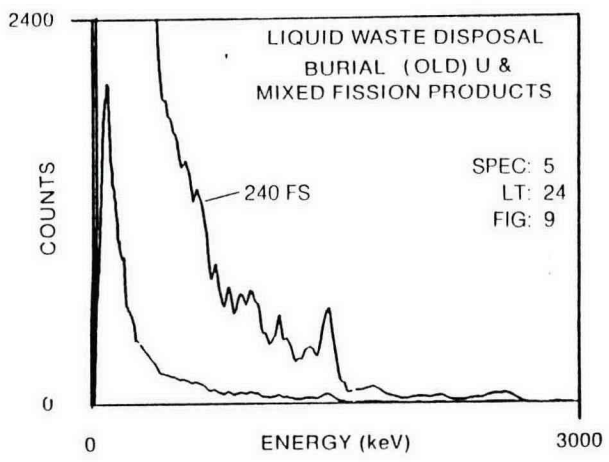
FIGURE 7. *LOCATIONS OF SCALED-UP ANOMALOUS AREAS*











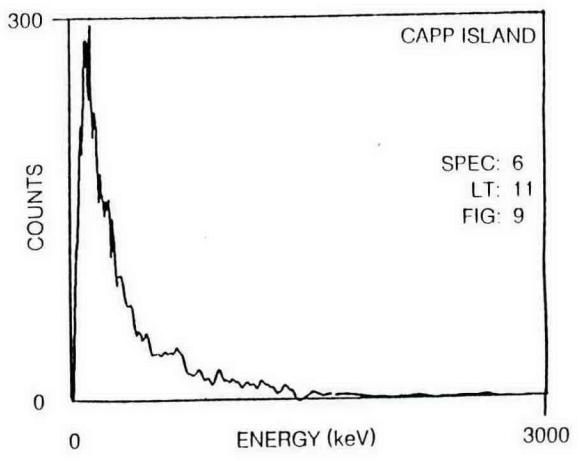


FIGURE 8. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 6 ON FIGURE 9, 300-AREA AND ADVANCED NUCLEAR FUELS***

FIGURE 9. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 300-AREA AND SURROUNDING AREA*

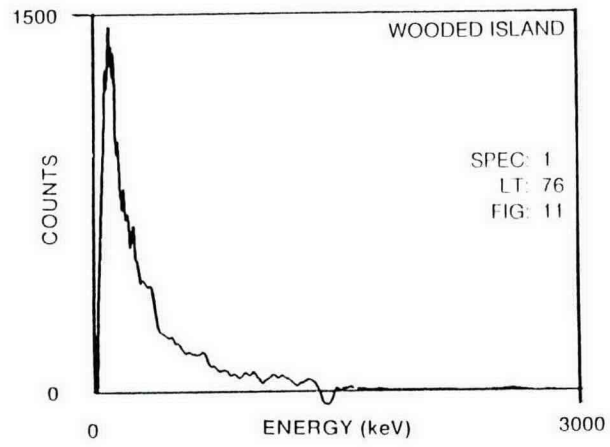
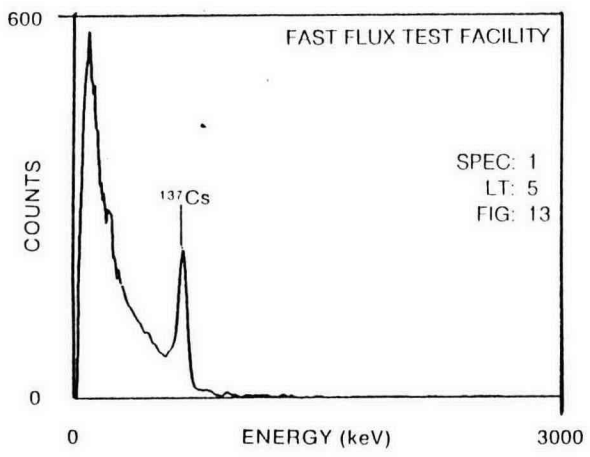
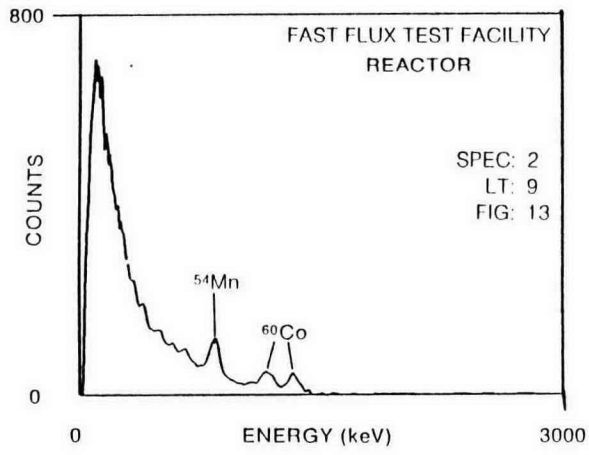
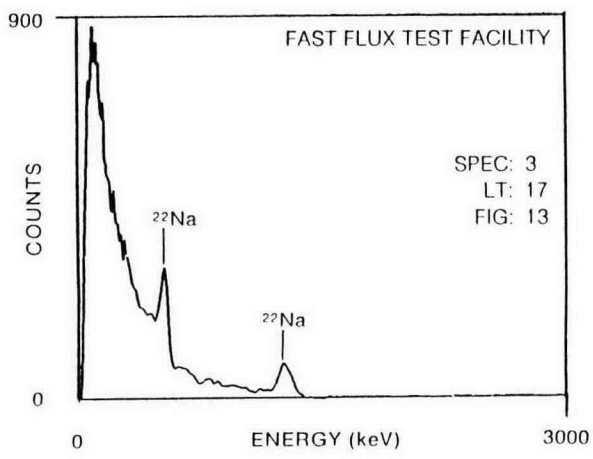


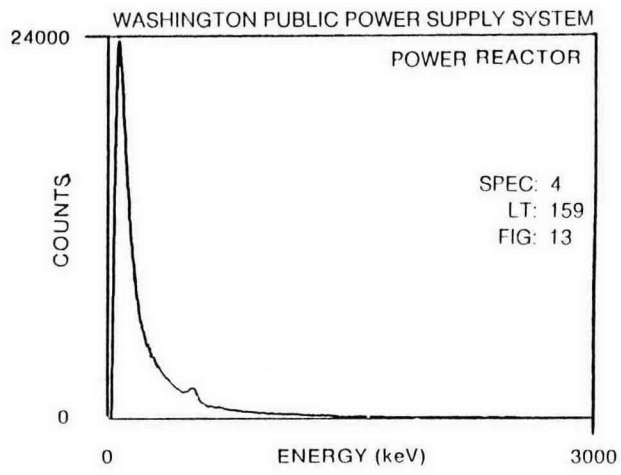
FIGURE 10. ***THIS SPECTRA CORRESPONDS TO NUMBER 1 ON FIGURE 11***

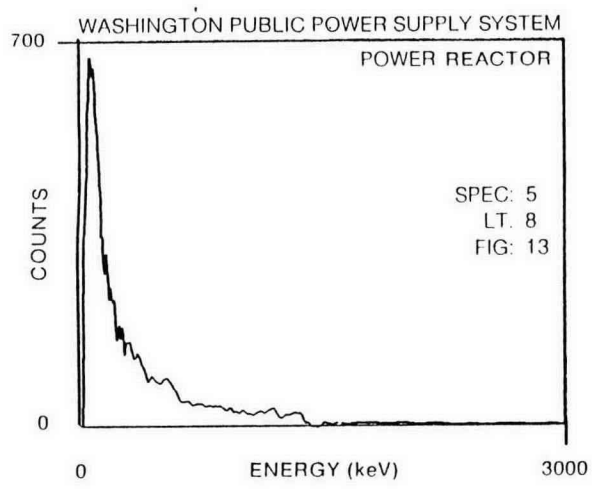
FIGURE 11. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF WOODED ISLAND*

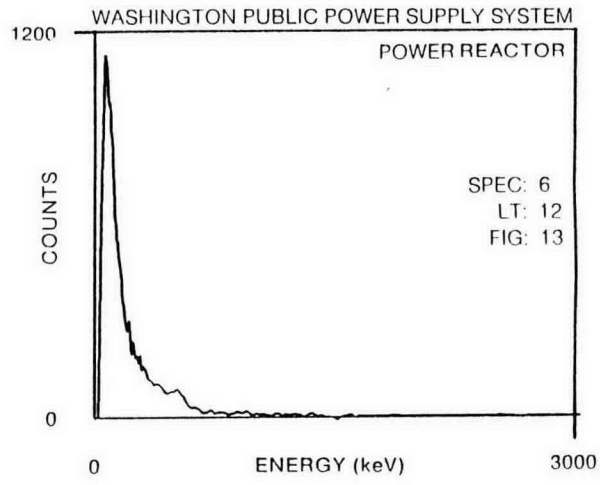












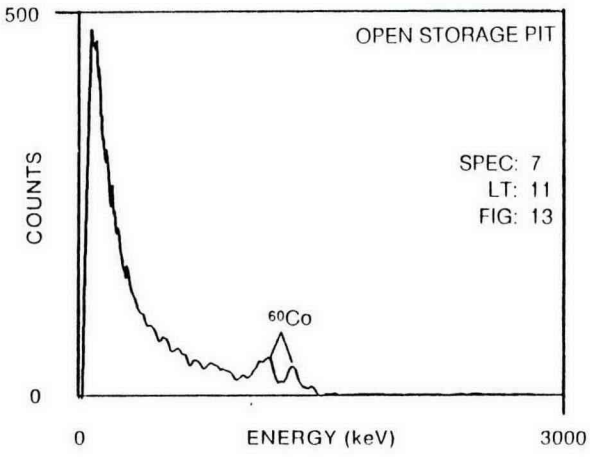


FIGURE 12. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 7 ON FIGURE 13, WPPSS AND 400-AREA FFTF***

MAN-MADE GROSS COUNT (MMGC) CONVERSION SCALE	
LETTER LABEL	**COUNTS PER SECOND**
A	< 700
B	700 – 2,200
C	2,200 – 7,000
D	7,000 – 22,000
E	22,000 – 70,000
F	70,000 – 220,000
G	220,000 – 700,000
H	700,000 – 2,200,000
I	2,200,000 – 7,000,000

The data shown here have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

LEGEND

NUMBERS 1 THROUGH 7 ON FIGURE 13 CORRESPOND TO SPECTRA 1 THROUGH 7 ON FIGURE 12

WPPSS

400-AREA
FFTF

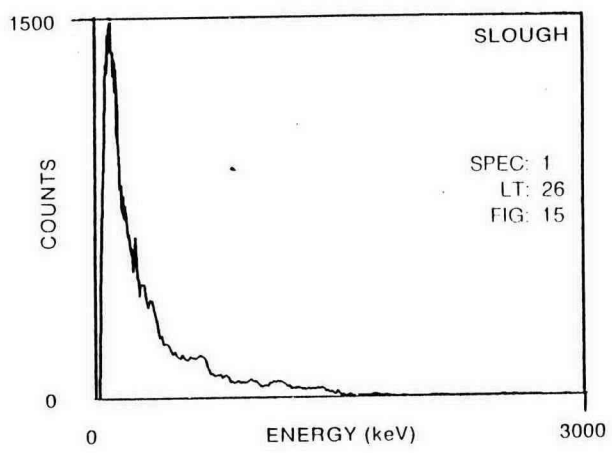
N

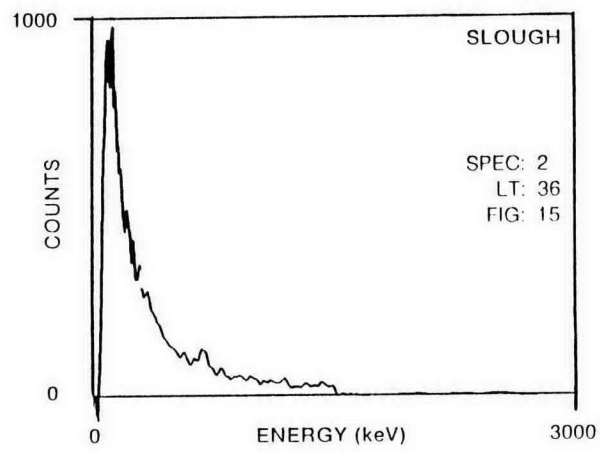
0 1000 2000 3000 4000 FEET

0 800 1600 METERS

FIGURE 13. ***ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 400-AREA AND WPPSS***

PHOTO DATE: JUNE 1988





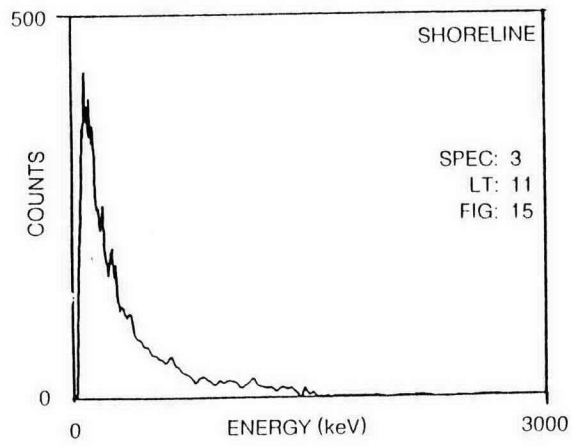
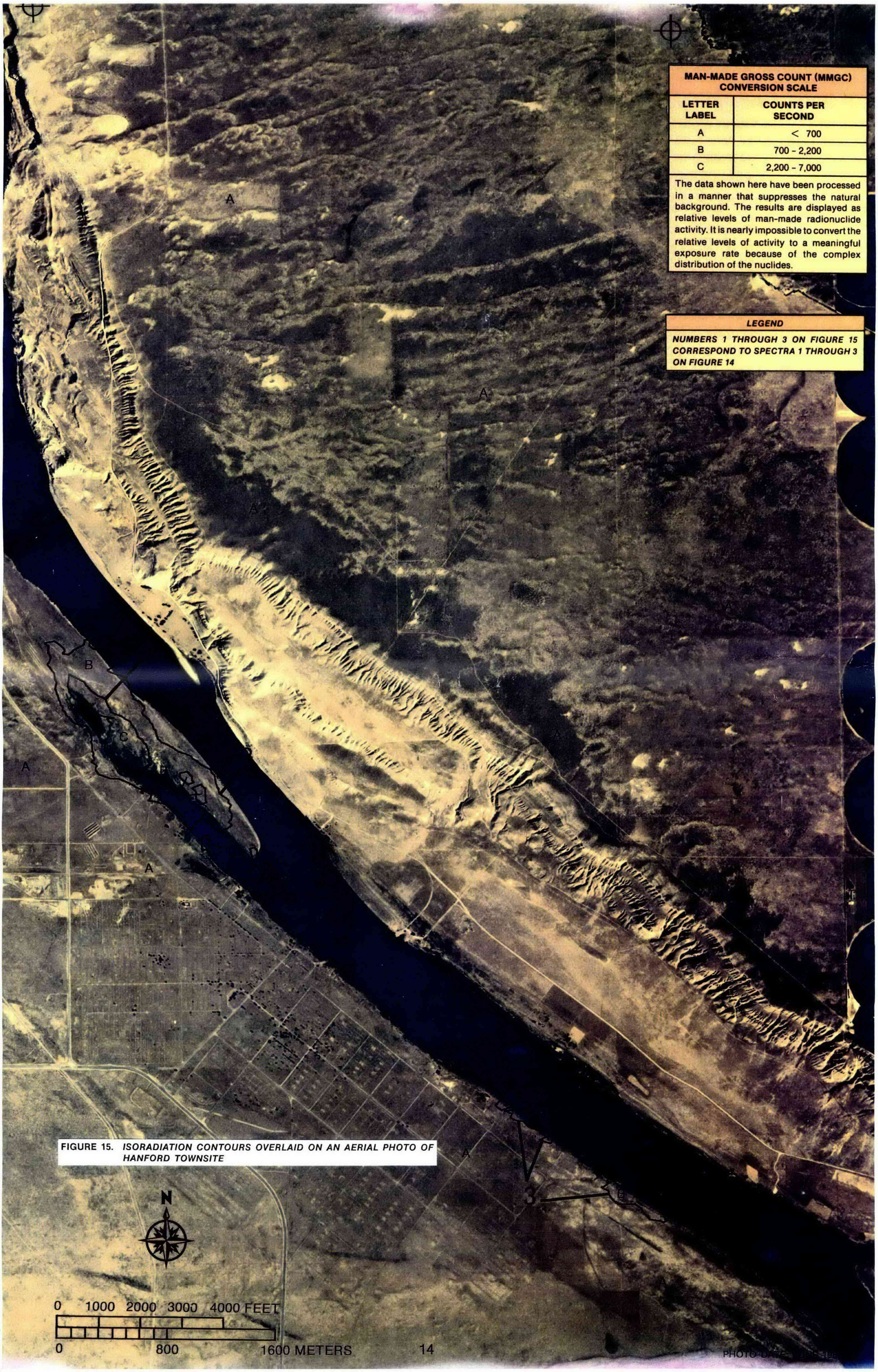


FIGURE 14. ***THESE SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 3 ON FIGURE 15***



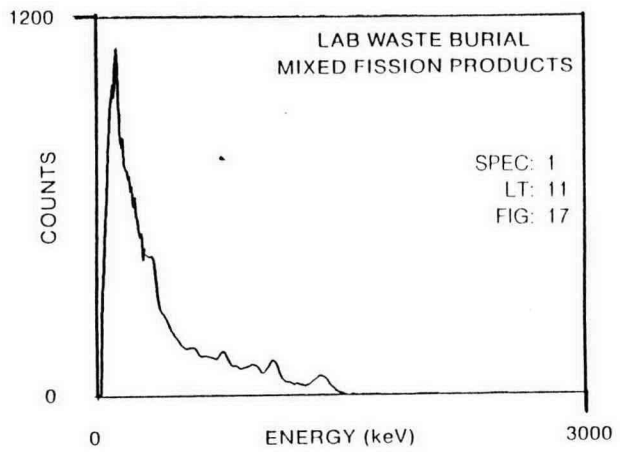
MAN-MADE GROSS COUNT (MMGC) CONVERSION SCALE	
LETTER LABEL	**COUNTS PER SECOND**
A	< 700
B	700 - 2,200
C	2,200 - 7,000

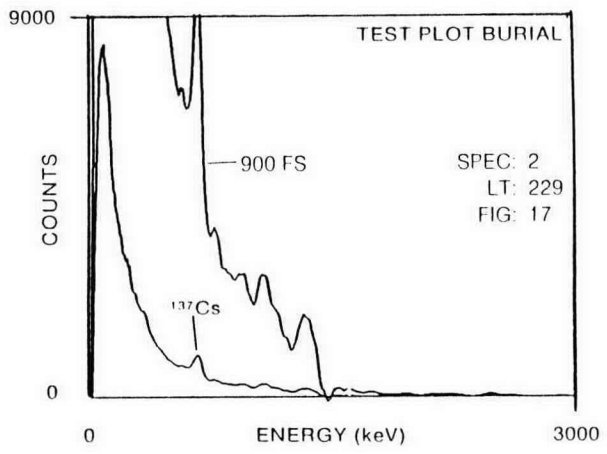
The data shown here have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

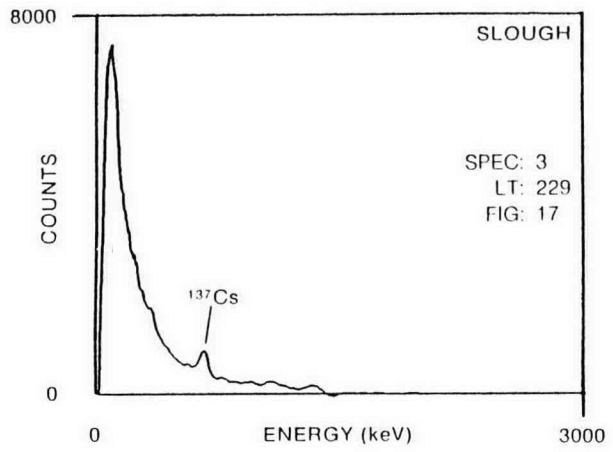
LEGEND

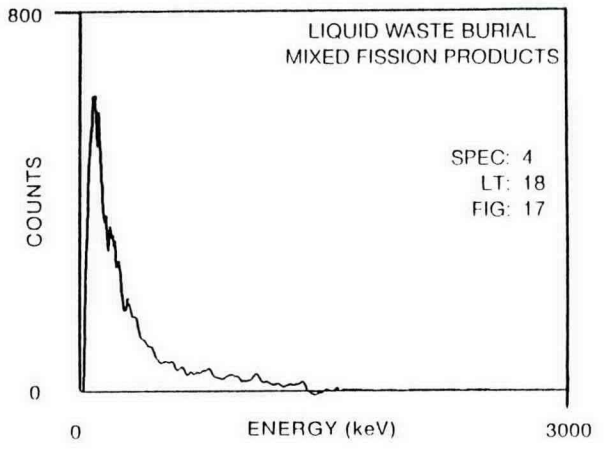
NUMBERS 1 THROUGH 3 ON FIGURE 15 CORRESPOND TO SPECTRA 1 THROUGH 3 ON FIGURE 14

FIGURE 15. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF HANFORD TOWNSITE*









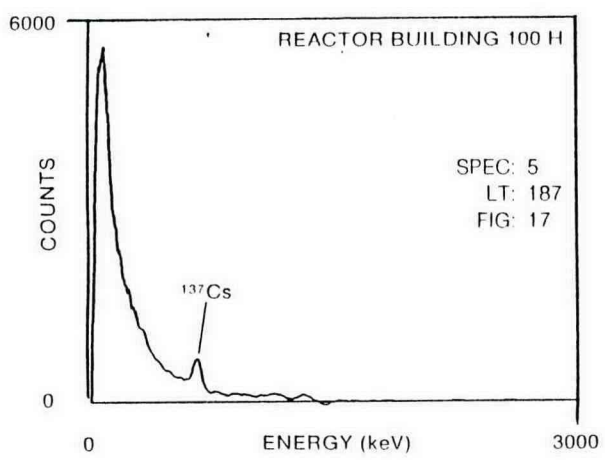
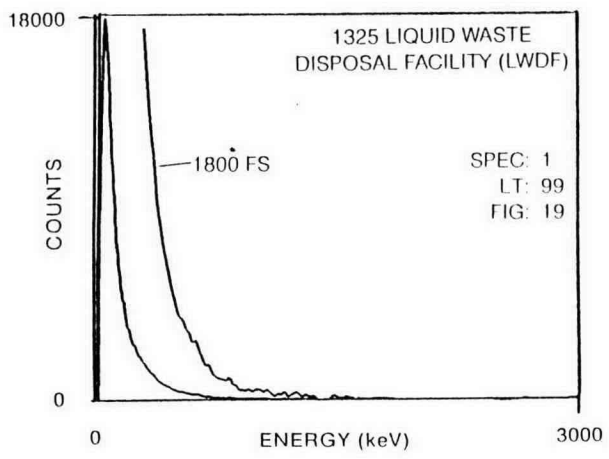
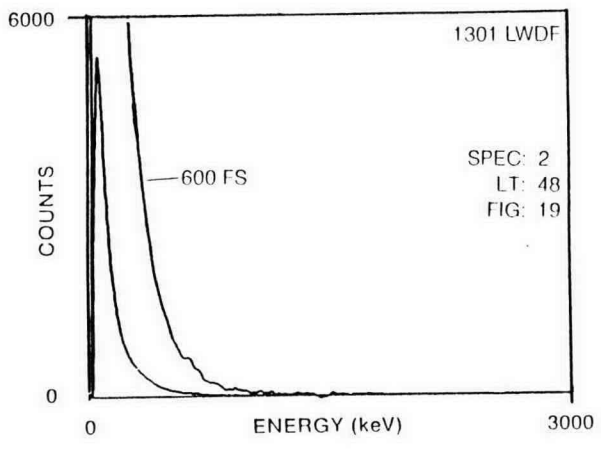
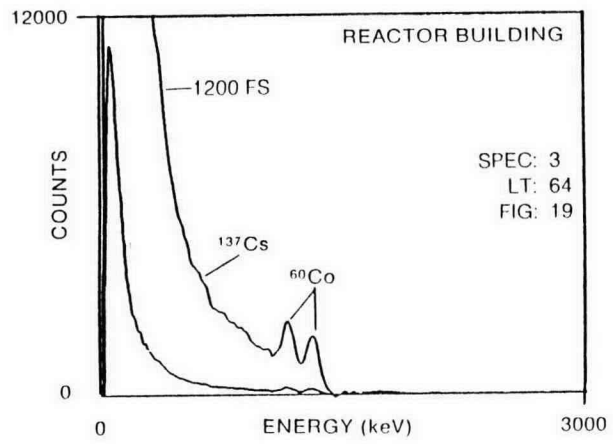


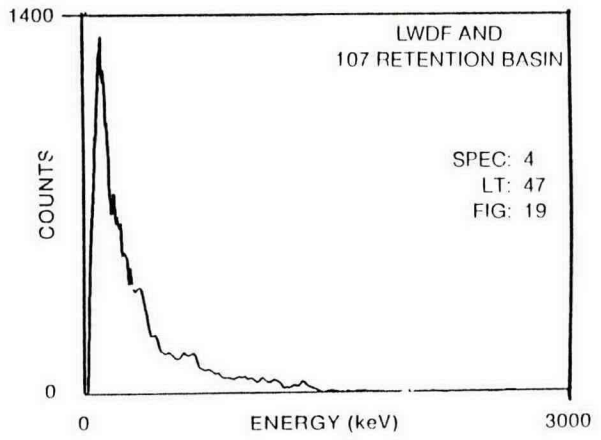
FIGURE 16. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 5 ON FIGURE 17, 100-H AREA AND 100-F AREA***

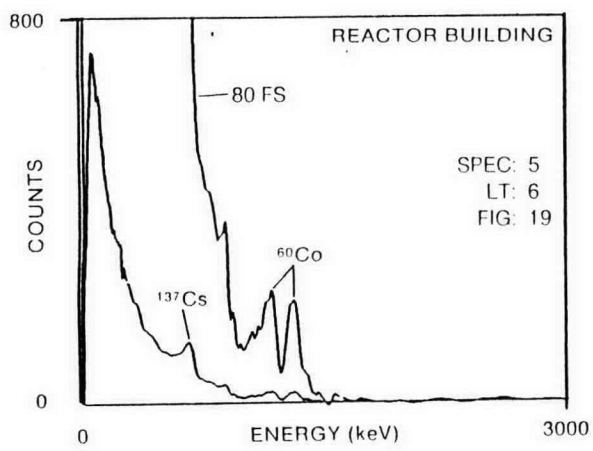
FIGURE 17. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 100-F AREA AND 100-H AREA*

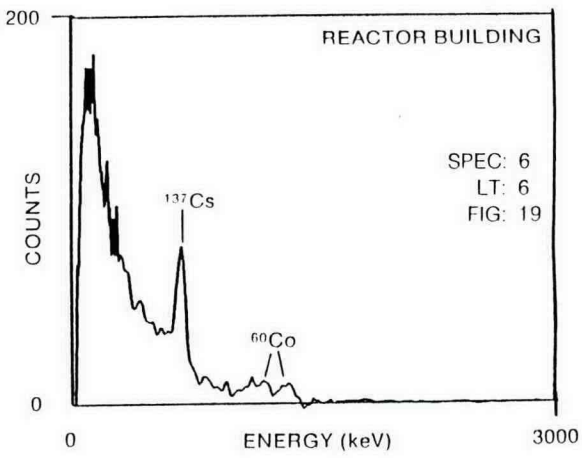












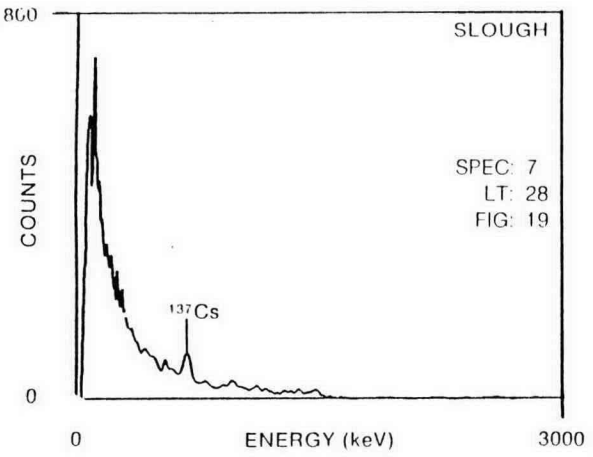


FIGURE 18. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 7 ON FIGURE 19, 100-N AREA AND 100-D & DR AREA***

MAN-MADE GROSS COUNT (MMGC) CONVERSION SCALE	
LETTER LABEL	COUNTS PER SECOND
A	< 700
B	700 – 2,200
C	2,200 – 7,000
D	7,000 – 22,000
E	22,000 – 70,000
F	70,000 – 220,000
G	220,000 – 700,000
H	700,000 – 2,200,000
I	2,200,000 – 7,000,000
J	7,000,000 – 22,000,000

The data shown here have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

LEGEND

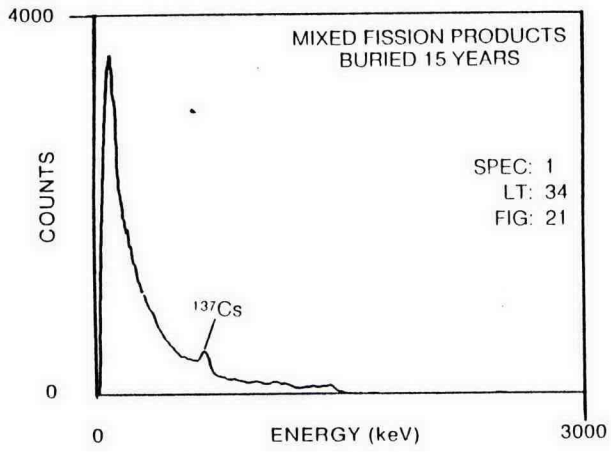
NUMBERS 1 THROUGH 7 ON FIGURE 19 CORRESPOND TO SPECTRA 1 THROUGH 7 ON FIGURE 18

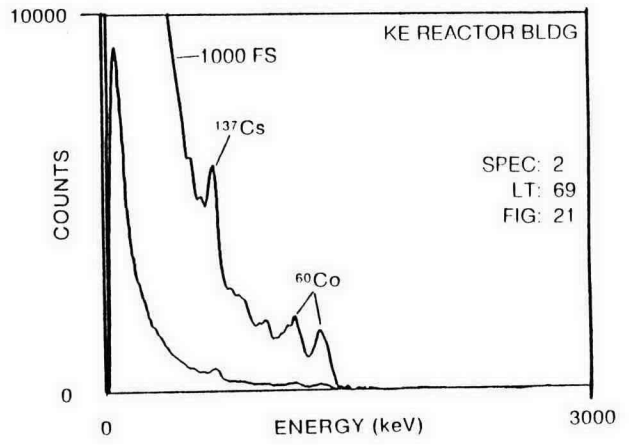
100-N AREA

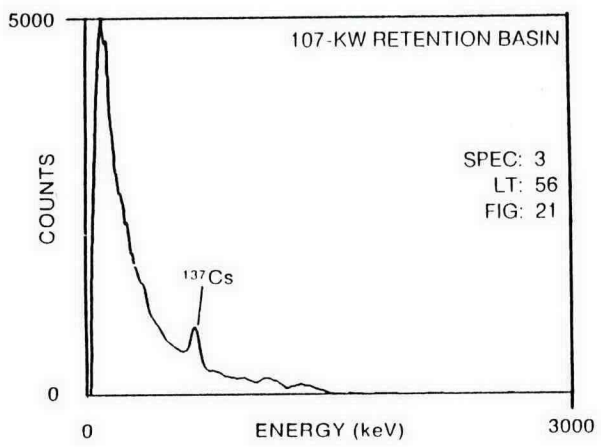
100-D & DR AREA

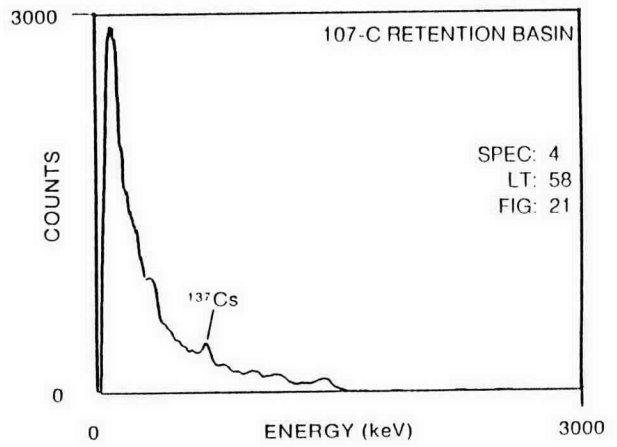
FIGURE 19. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 100-N AREA AND 100-D & DR AREA*

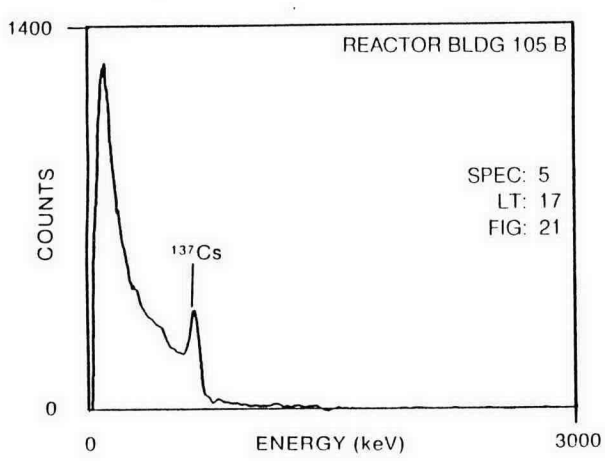
PHOTO DATE: JUNE 1988











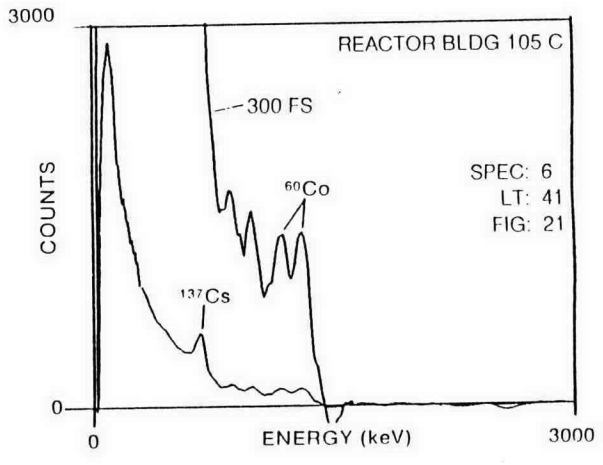


FIGURE 20. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 6 ON FIGURE 21, 100-KW & KE AREA AND 100-B & C AREA***

MAN-MADE GROSS COUNT (MMGC) CONVERSION SCALE	
LETTER LABEL	**COUNTS PER SECOND**
A	< 700
B	700 - 2,200
C	2,200 - 7,000
D	7,000 - 22,000
E	22,000 - 70,000
F	70,000 - 220,000

The data shown here have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

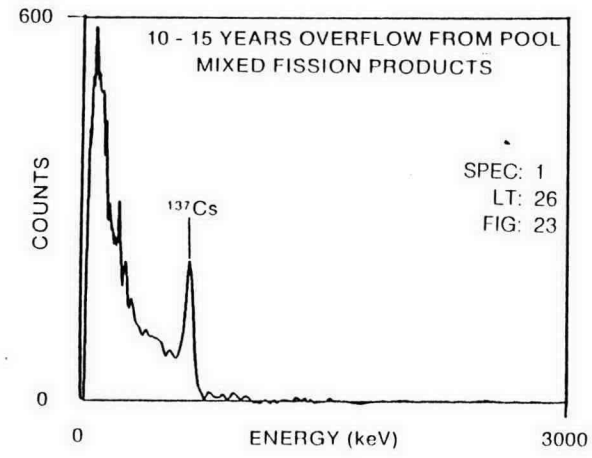
LEGEND
NUMBERS 1 THROUGH 6 ON FIGURE 21 CORRESPOND TO SPECTRA 1 THROUGH 6 ON FIGURE 20

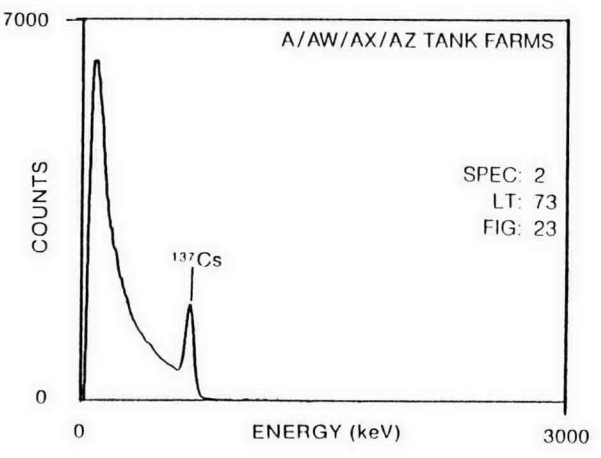
100-KW & KE AREA

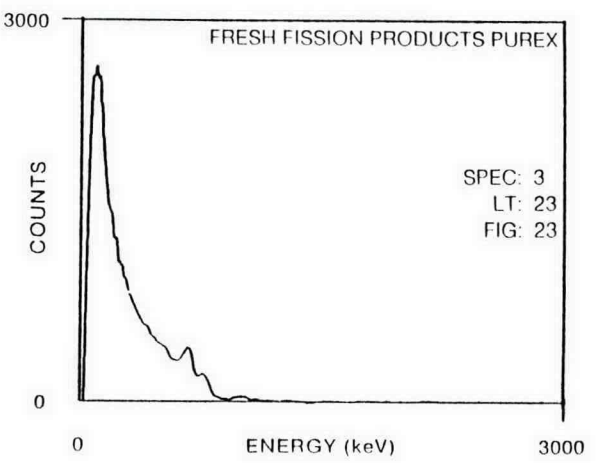
100-B & C AREA

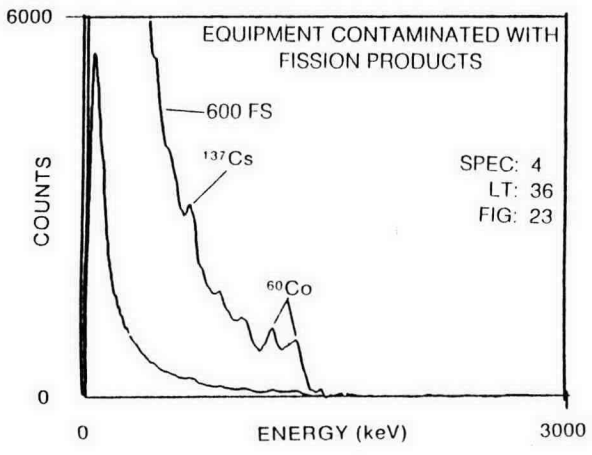
FIGURE 21. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 100-B & C AREAS AND 100-KW & KE AREAS*

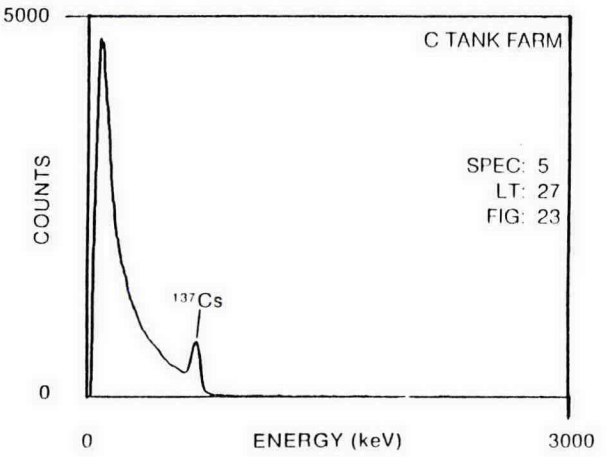
PHOTO DATE: JUNE 1988

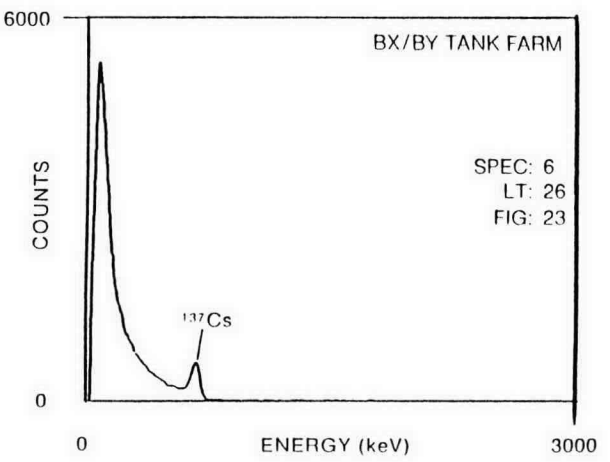


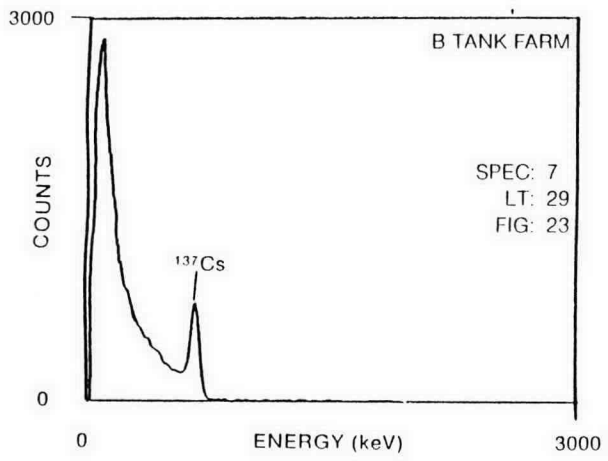


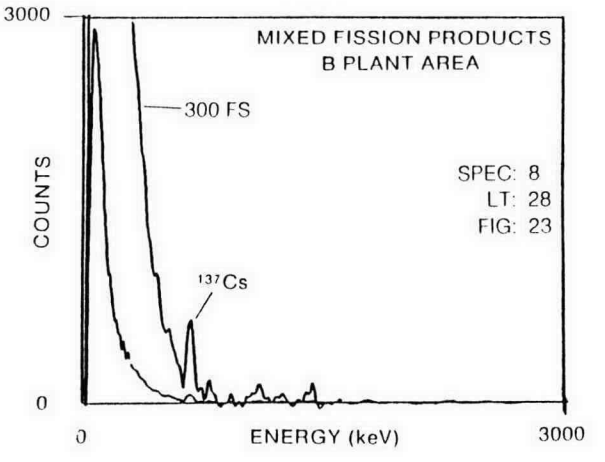


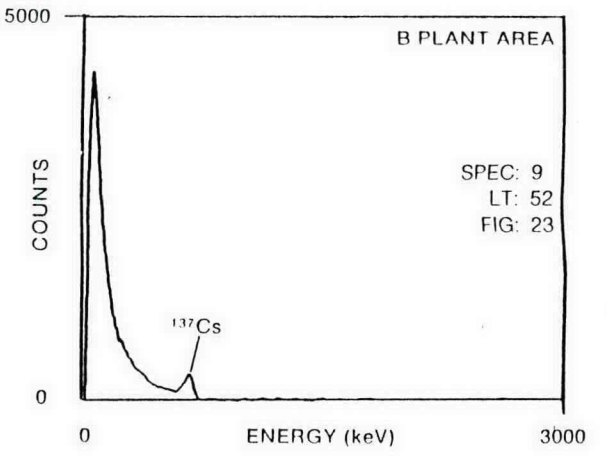


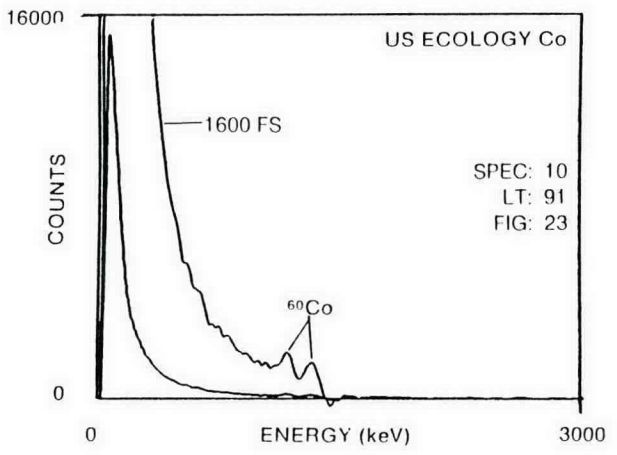












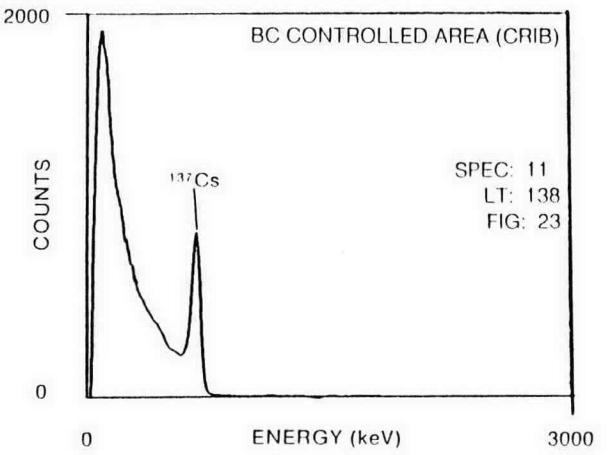


FIGURE 22. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 11 ON FIGURE 23, 200-EAST AREA***

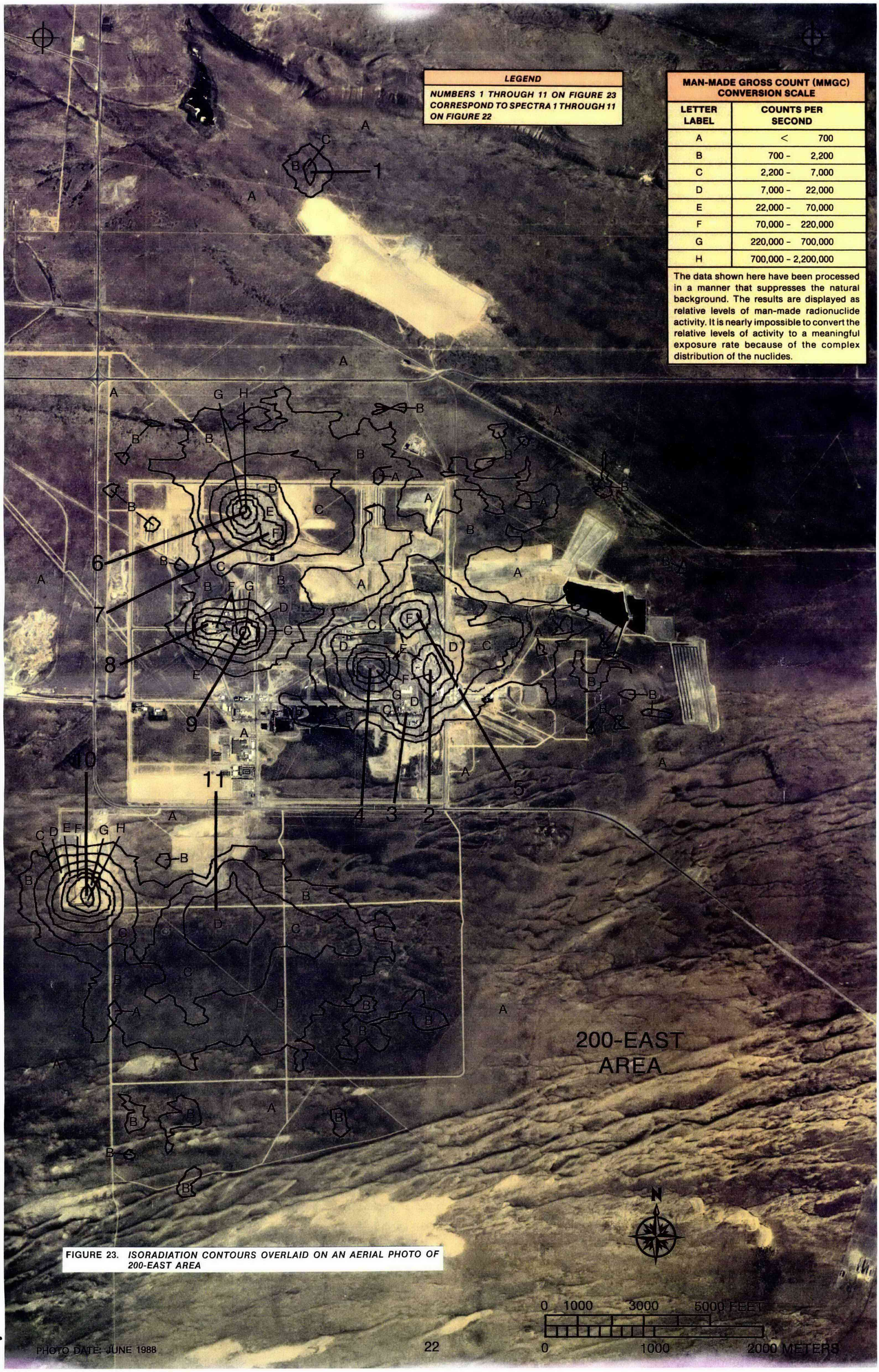
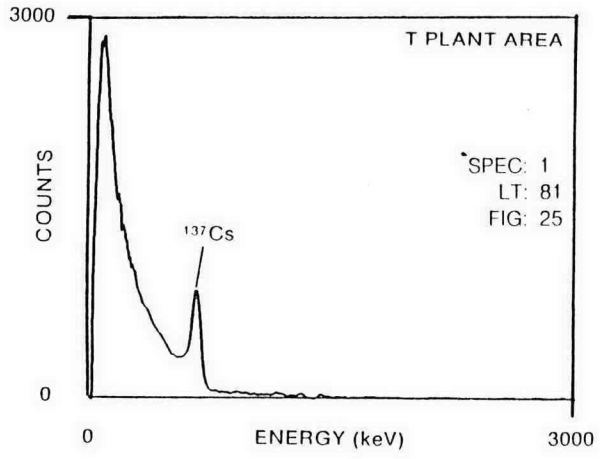
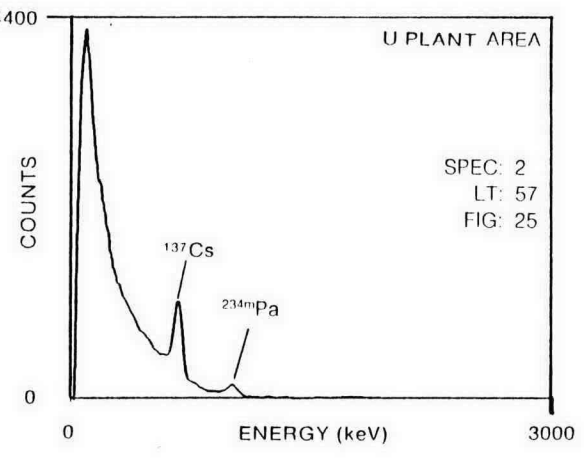
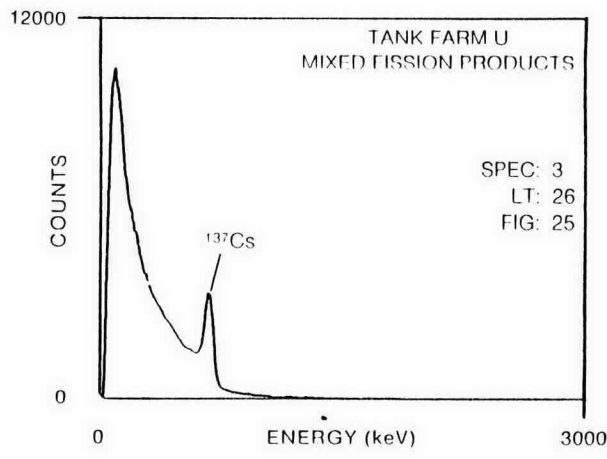
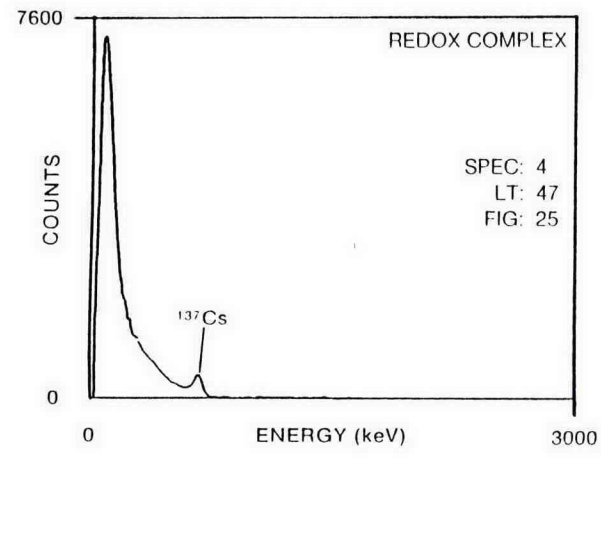


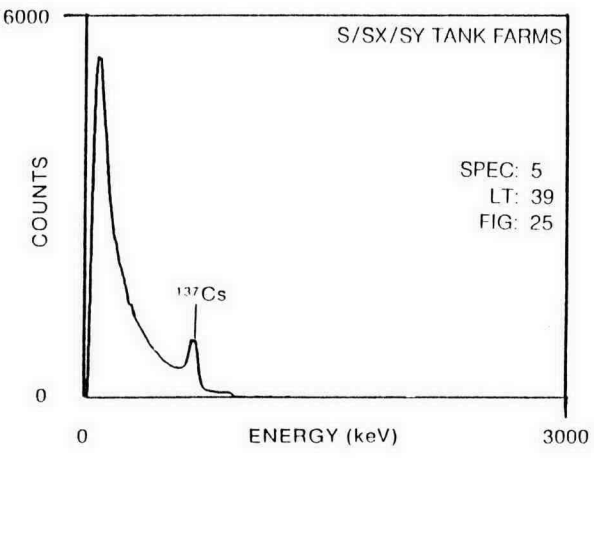
FIGURE 23. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 200-EAST AREA*

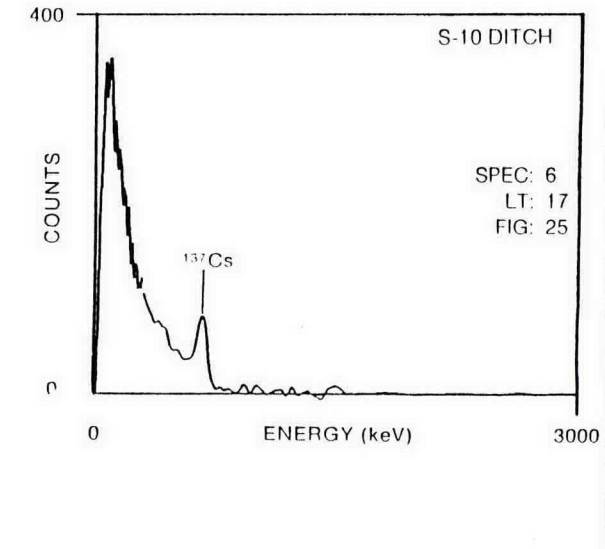


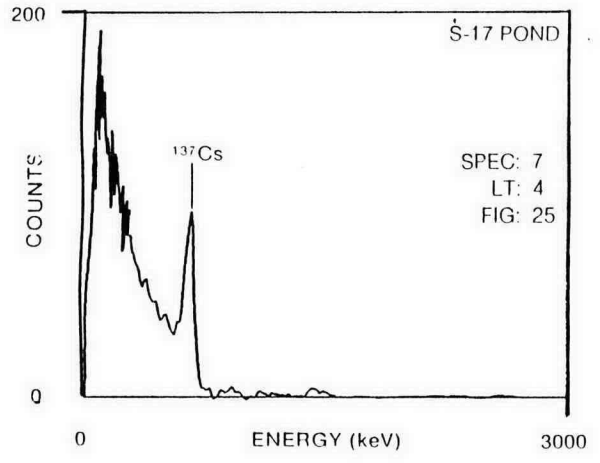


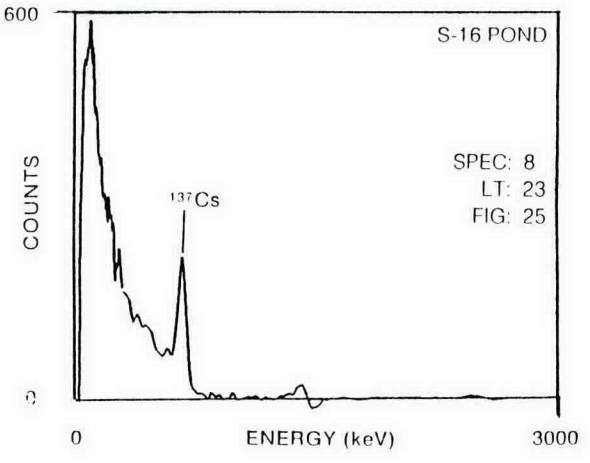


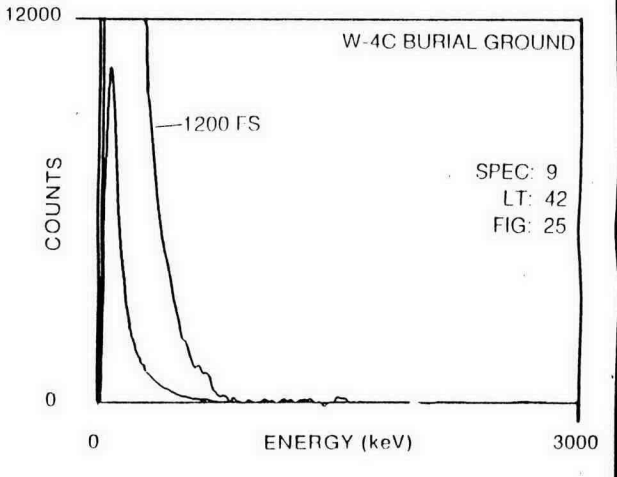


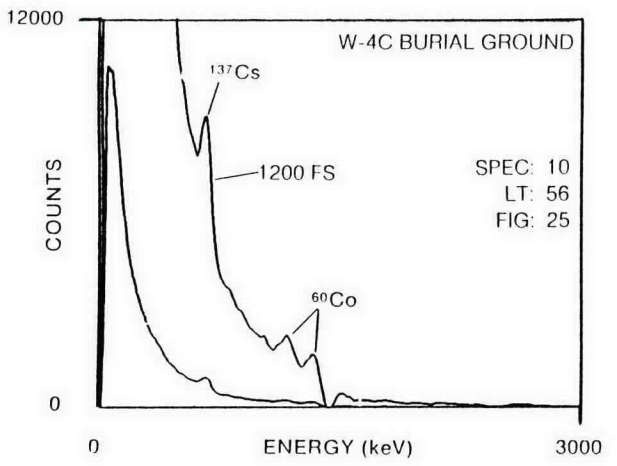


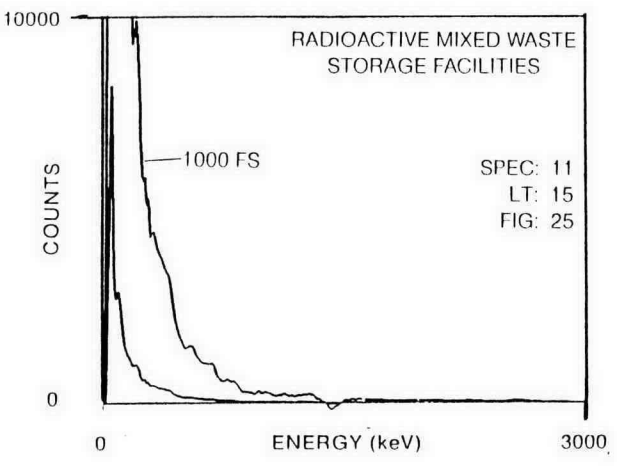


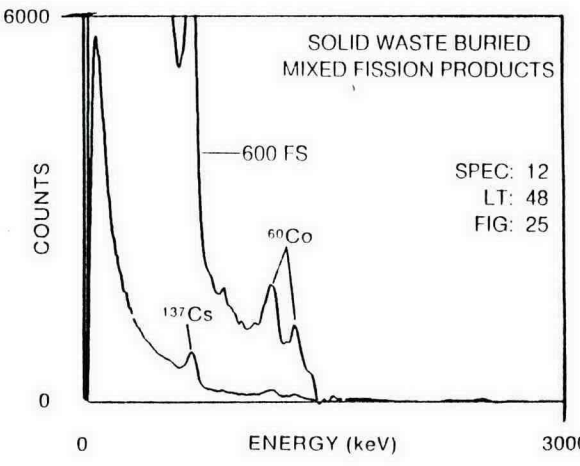


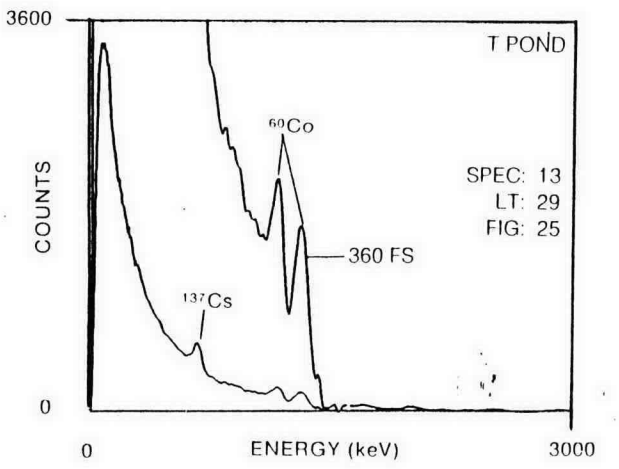


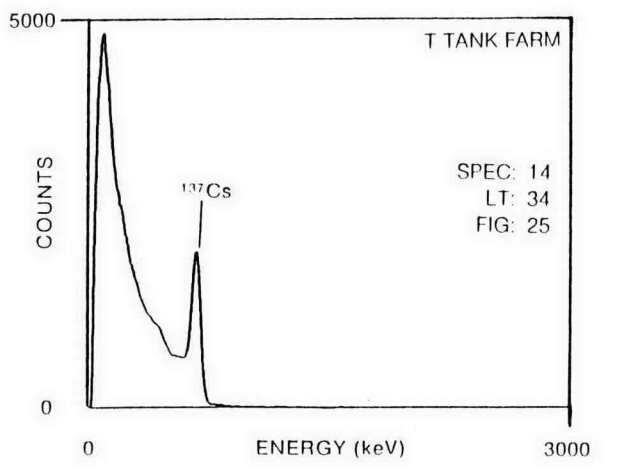












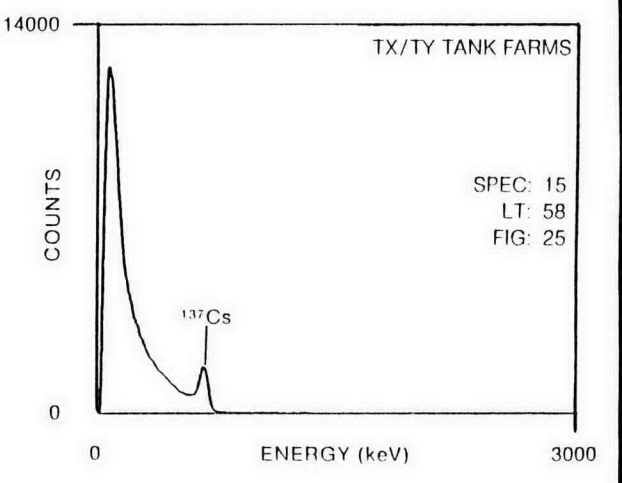


FIGURE 24. ***SPECTRA CORRESPOND TO NUMBERS 1 THROUGH 15 ON FIGURE 25, 200-WEST AREA***

MAN-MADE GROSS COUNT (MMGC) CONVERSION SCALE	
LETTER LABEL	COUNTS PER SECOND
A	< 700
B	700 - 2,200
C	2,200 - 7,000
D	7,000 - 22,000
E	22,000 - 70,000
F	70,000 - 220,000
G	220,000 - 700,000
H	700,000 - 2,200,000

The data shown here have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

LEGEND
NUMBERS 1 THROUGH 15 ON FIGURE 25 CORRESPOND TO SPECTRA 1 THROUGH 15 ON FIGURE 24

FIGURE 25. *ISORADIATION CONTOURS OVERLAID ON AN AERIAL PHOTO OF 200-WEST AREA*

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1. Lindeken, C. L., *et al.* 1972. "Geographical Variations in Environmental Radiation Background in the United States." *Proceedings of the Second International Symposium on the Natural Radiation Environment*. 7-11 August 1972, Houston, Texas: pp. 317-332. Springfield, VA: National Technical Information Service, U.S. Department of Commerce.

2. Feimster, E.L., and Hilton, L.K. September 1982. *An Aerial Radiological Survey of the U.S. Department of Energy's Hanford Site, Richland, Washington*, Date of Survey: May/June 1978. Report No. EGG-1183-1828. Las Vegas, NV: EG&G/EM.

3. Tipton, W.J. April 1975. *An Aerial Radiological Survey of the U.S. Energy Research and Development Administration's Hanford Reservation*, Survey Period: 1973–1974. Report No. EGG-1183-1661. Las Vegas, NV: EG&G/EM.